Operative Techniques in Thoracic and Cardiovascular Surgery

Extra-anatomic Bypass Graft for Recurrent Aortic Arch Obstruction

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Excellent results for repair of aortic arch obstruction have been achieved in the majority of centers in the current era; however, recurrent obstruction is a potential problem and the treatment options can be controversial in regards to the best approach,[1] particularly when the obstructed segment is long and/or involves arch vessels. The recommended indication for intervention includes a peak-to-peak coarctation gradient of at least 20 mm Hg[2]; however, the presence of low gradient does not preclude the need for intervention secondary to the presence of collaterals. In this setting, a diameter of less than half the aortic diameter at the diaphragm favors intervention. The presence of hypertension, left ventricular hypertrophy, or exercise-related hypertension should also be considered when deciding on the need for intervention. Extra-anatomic bypass graft from the ascending to the descending thoracic aorta represents a valuable option that avoids direct reintervention on the aortic arch or isthmus and can achieve excellent results with no residual gradient and minimal morbidity.[3] In this article, we describe our technique of ascending-to-descending aortic bypass through the posterior pericardial approach.

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Surgical Technique

After induction of general endotracheal anesthesia and placement of routine monitoring lines (includes right radial and femoral artery) needed for the cardiac surgical procedure, a standard median sternotomy is performed. Transesophageal echocardiogram is routinely used. Cardiopulmonary bypass is used to facilitate manipulation of the heart within the pericardial well without causing any hemodynamic instability. Our preferred cannulation strategy is an arterial cannula high in the ascending aorta and right-angle bicaval cannulae. Normothermia or a mild degree of hypothermia is typically used. Certain maneuvers are helpful to expose the descending thoracic aorta through the posterior pericardium. This may include opening the right pleural space and cutting the right lateral pericardium posteriorly. We prefer bicaval cannulation as this allows the heart to be positioned out of the pericardial well and dropped into the right pleural space without compromising the venous return. This further facilitates

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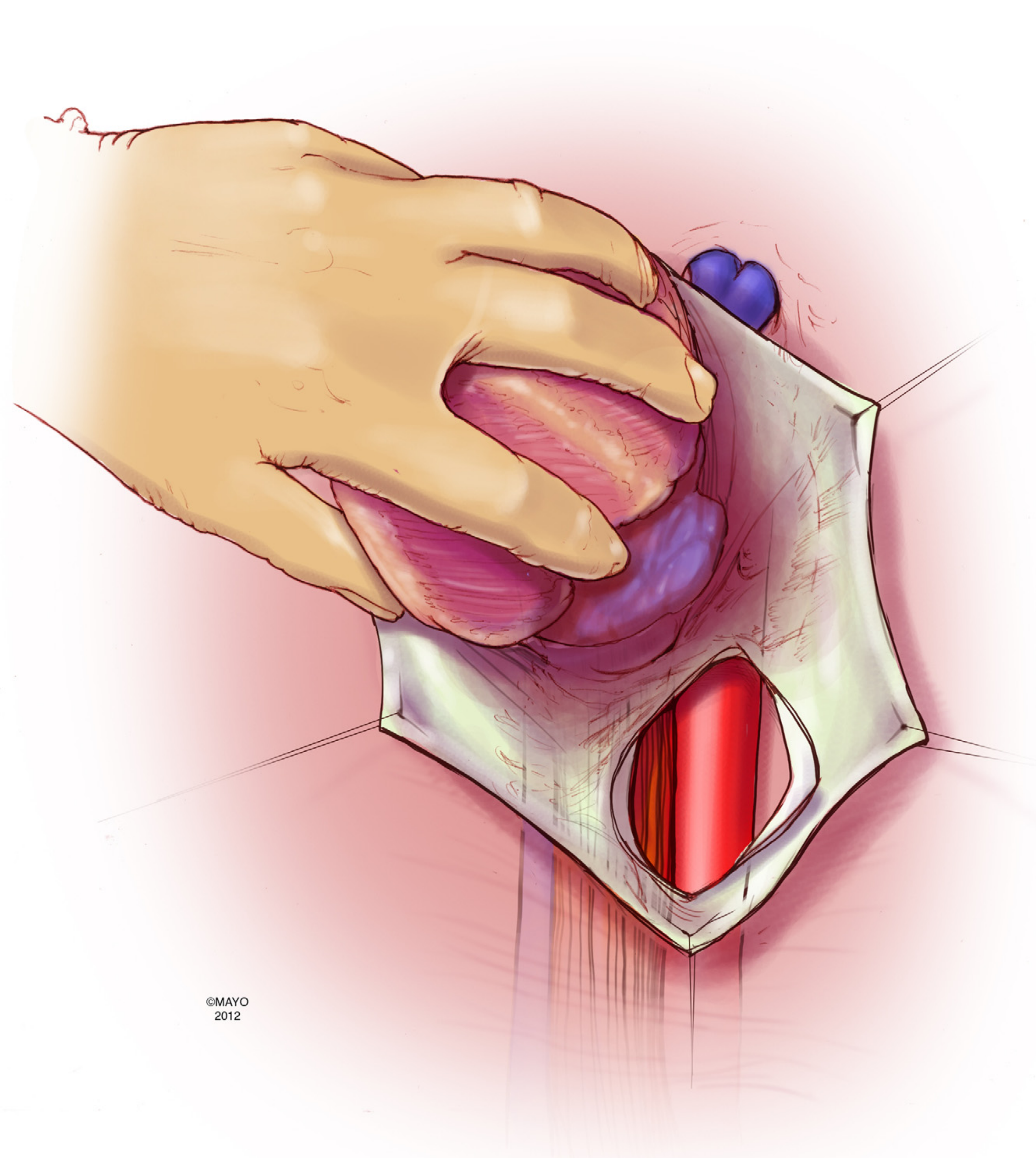

Figure 1 The heart is elevated out of the pericardial well and into the right hemithorax. A longitudinal incision is made in the posterior pericardium, exposing the descending thoracic aorta just cephalad to the diaphragm and leftward of the esophagus. Attention should be given to the nearby esophagus, which can be identified by the transesophageal echocardiography probe or a nasogastric tube. (Used by permission of Mayo Foundation for Medical Education and Research. All rights reserved.) (Color version of figure is available online at http://www.optechtcs.com.)

exposure of the distal descending thoracic aorta for construction of the distal anastomosis. To avoid left ventricular distension when the heart is rotated rightward, a right superior pulmonary vein left ventricular vent may be used. Cardioplegic arrest is not necessary and the heart is usually left beating and perfused. Aortic occlusion and cardioplegic arrest is reserved for concomitant intracardiac procedures. The posterior pericardium is opened in a longitudinal fashion over the descending thoracic aorta just cephalad to the diaphragm (Fig. 1). The descending aorta is usually small. It is critical to avoid injury to the nearby esophagus; the presence of the transesophageal echocardiography probe or nasogastric tube may help its identification. Once a satisfactory segment of the descending thoracic aorta is exposed, a side-biting vascular clamp is applied (Fig. 2). The femoral arterial pressure should be at least 40 mm Hg, which confirms adequate distal perfusion and nontotal occlusion of the descending aorta with the vascular clamp. The graft size is then determined

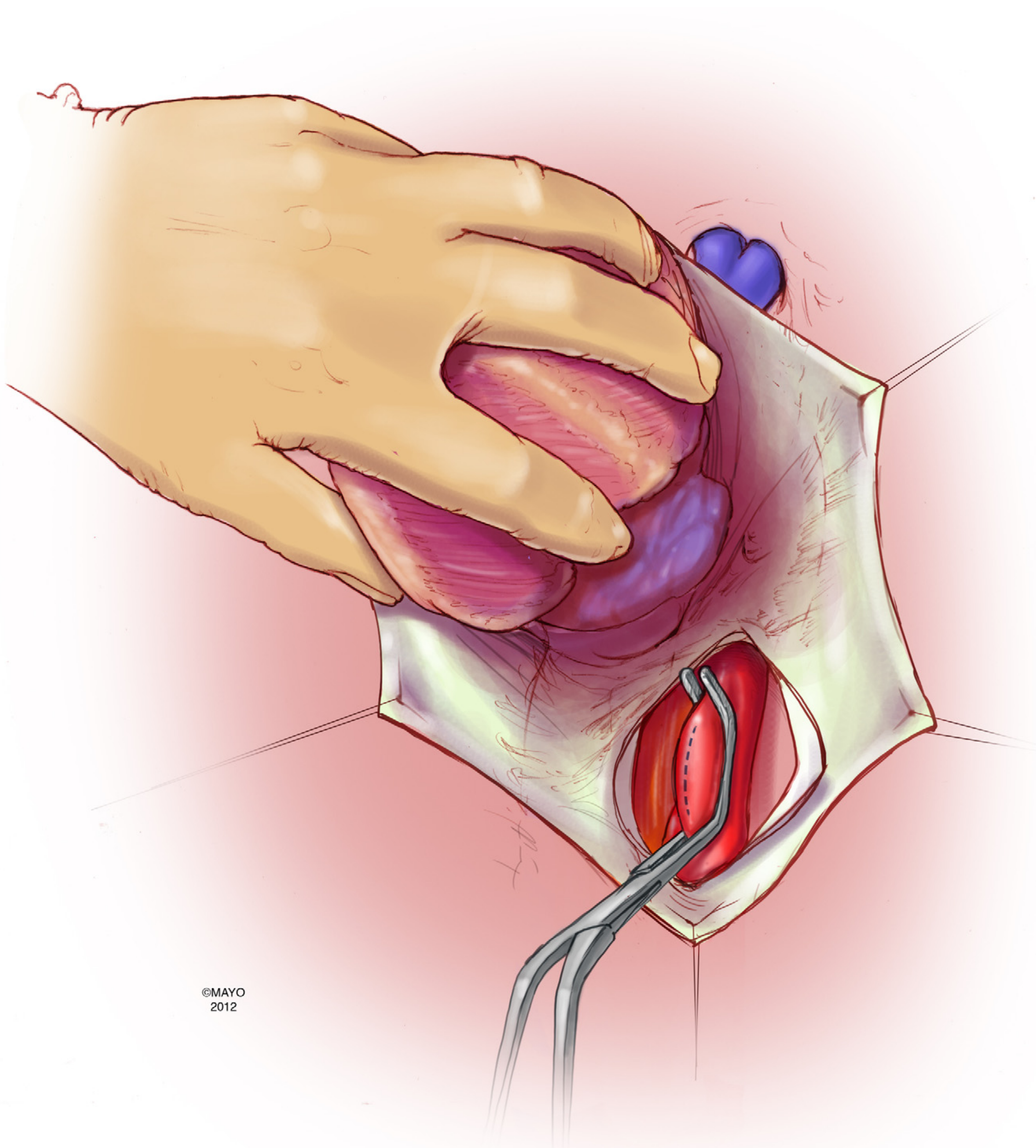

Figure 2 An adequate area of the distal descending thoracic aorta is chosen for the distal anastomosis and a side-biting vascular clamp is applied. The length of the jaws of the clamp should be much longer than the width of the selected graft. The femoral arterial pressure should be at least 40 mm Hg to ensure adequate distal perfusion. (Used by permission of Mayo Foundation for Medical Education and Research. All rights reserved.) (Color version of figure is available online at http://www.optechtcs.com.)

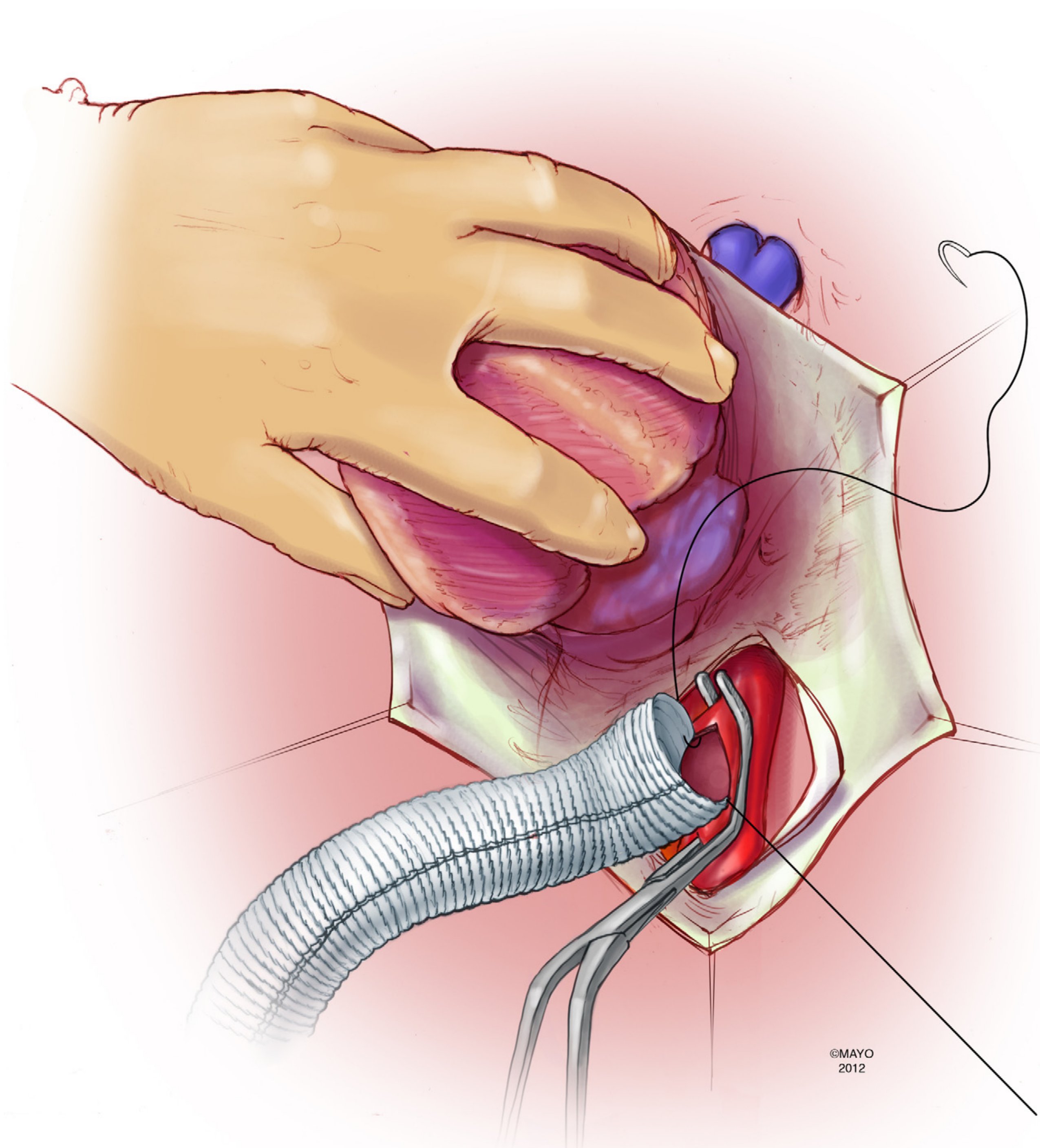

Figure 3 The distal anastomosis is constructed using continuous 4-0 polypropylene suture. The aorta can be quite fragile and care must be taken to avoid excessive pulling of the suture through the delicate aortic tissue. (Used by permission of Mayo Foundation for Medical Education and Research. All rights reserved.) (Color version of figure is available online at http://www.optechtcs.com.)

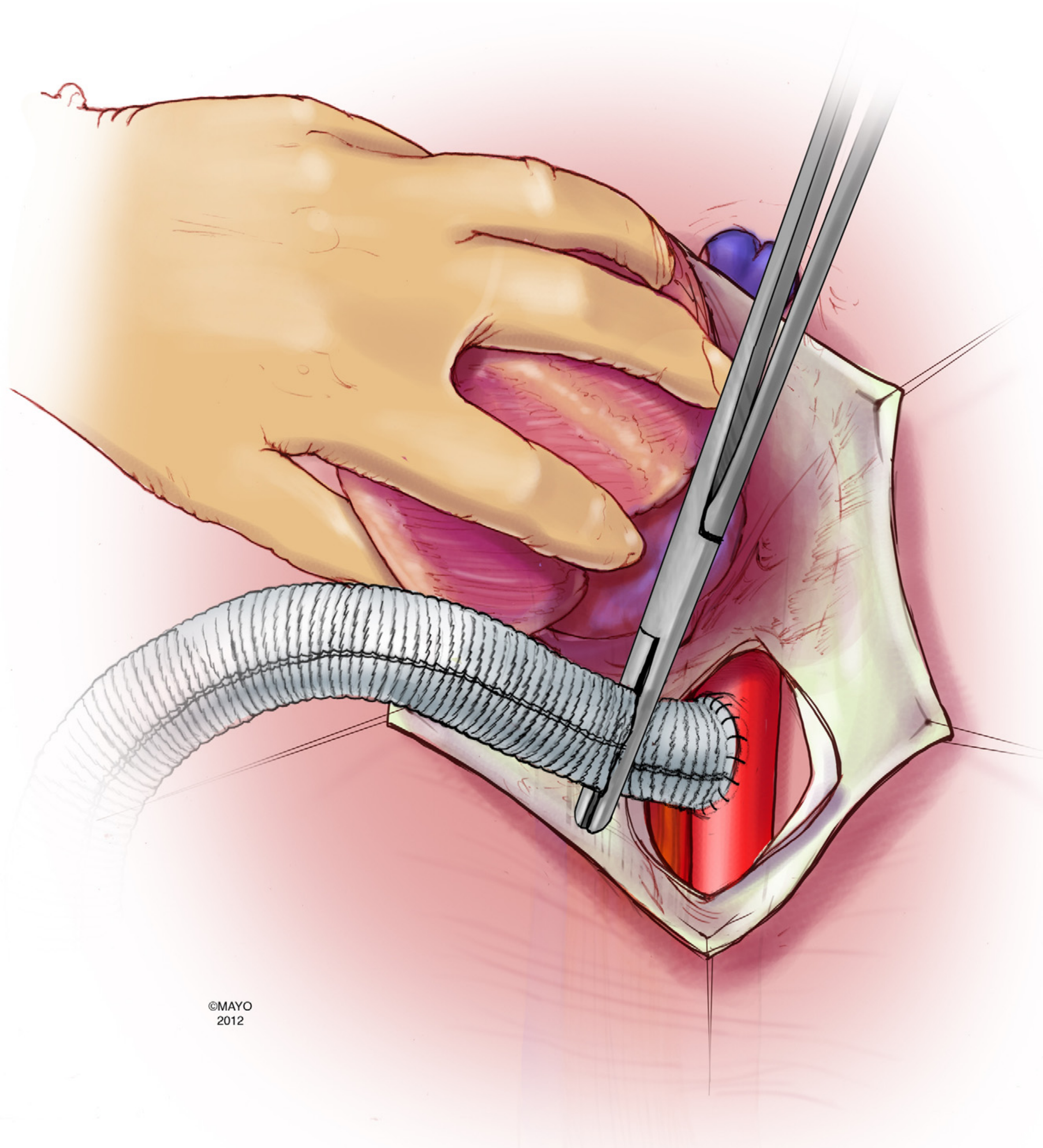

Figure 4 The graft is then de-aired and hemostasis is meticulously ensured. This area is difficult to access once the heart is positioned in the pericardial cavity and cardiopulmonary bypass is terminated. A piece of in situ pericardium is placed in between the esophagus and graft (not shown). (Used by permission of Mayo Foundation for Medical Education and Research. All rights reserved.) (Color version of figure is available online at http://www.optechtcs.com.)

based on the size of the descending aorta; it is usually 16, 18, or 20 mm. A longitudinal aortotomy is made and a distal end-to-side anastomosis is performed with a running 4-0 polypropylene suture (Fig. 3). The graft is then de-aired and hemostasis is ensured (Fig. 4). Importantly, we interpose intact posterior pericardium between the esophagus and

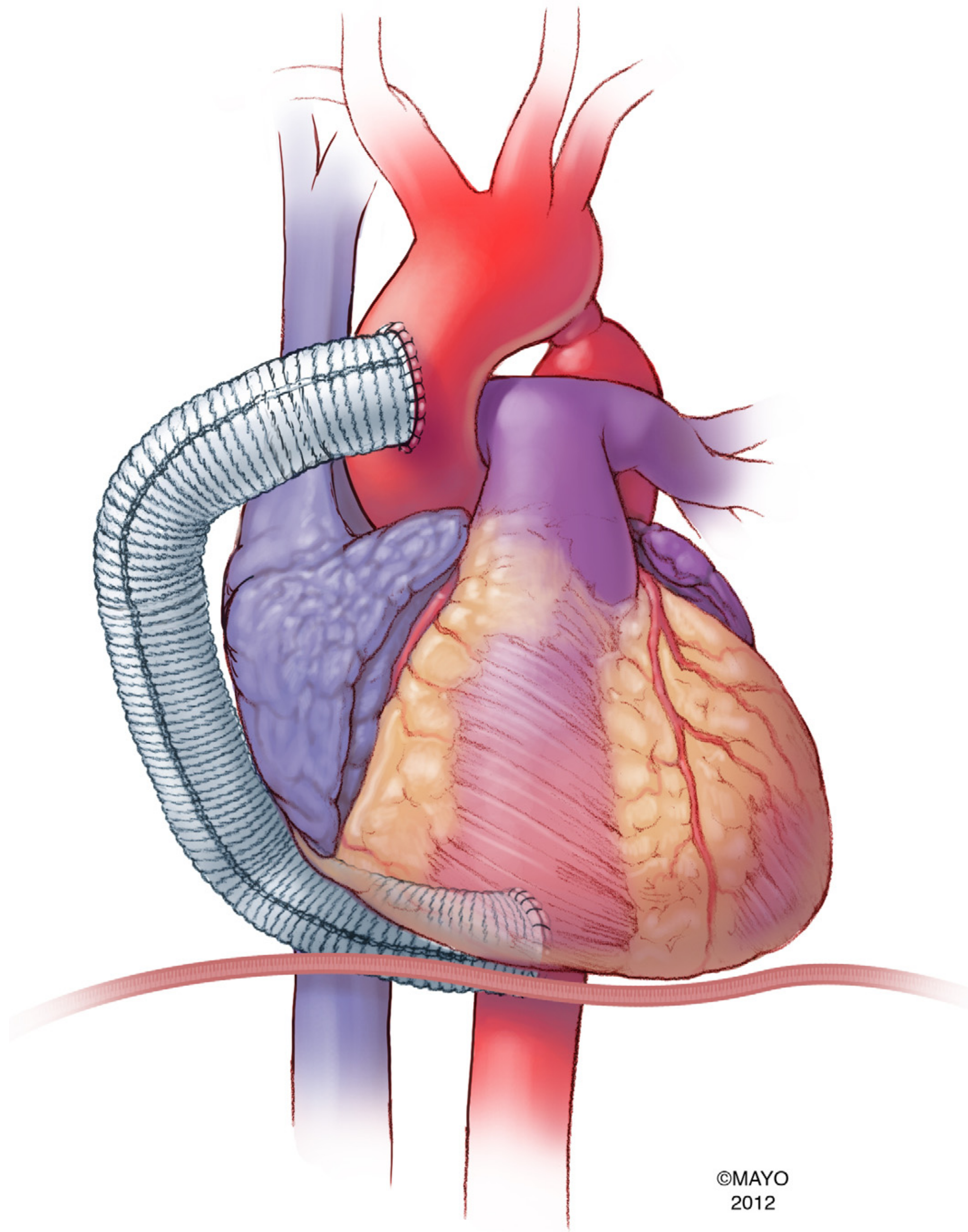

Figure 5 The graft can be routed to the right side anterior to the inferior vena cava and right pulmonary veins along the free wall of the right atrium. (Used by permission of Mayo Foundation for Medical Education and Research. All rights reserved.) (Color version of figure is available online at http://www.optechtcs.com.)

graft with a few tacking sutures to isolate the anastomosis from the esophageal wall. There are 3 different routes for the graft to be positioned to perform the proximal anastomosis. It can pass anterior (Fig. 5) or posterior (Fig. 6) to the inferior vena cava on the right side along the free wall of the right atrium (our preference). Alternatively, it can pass to the left

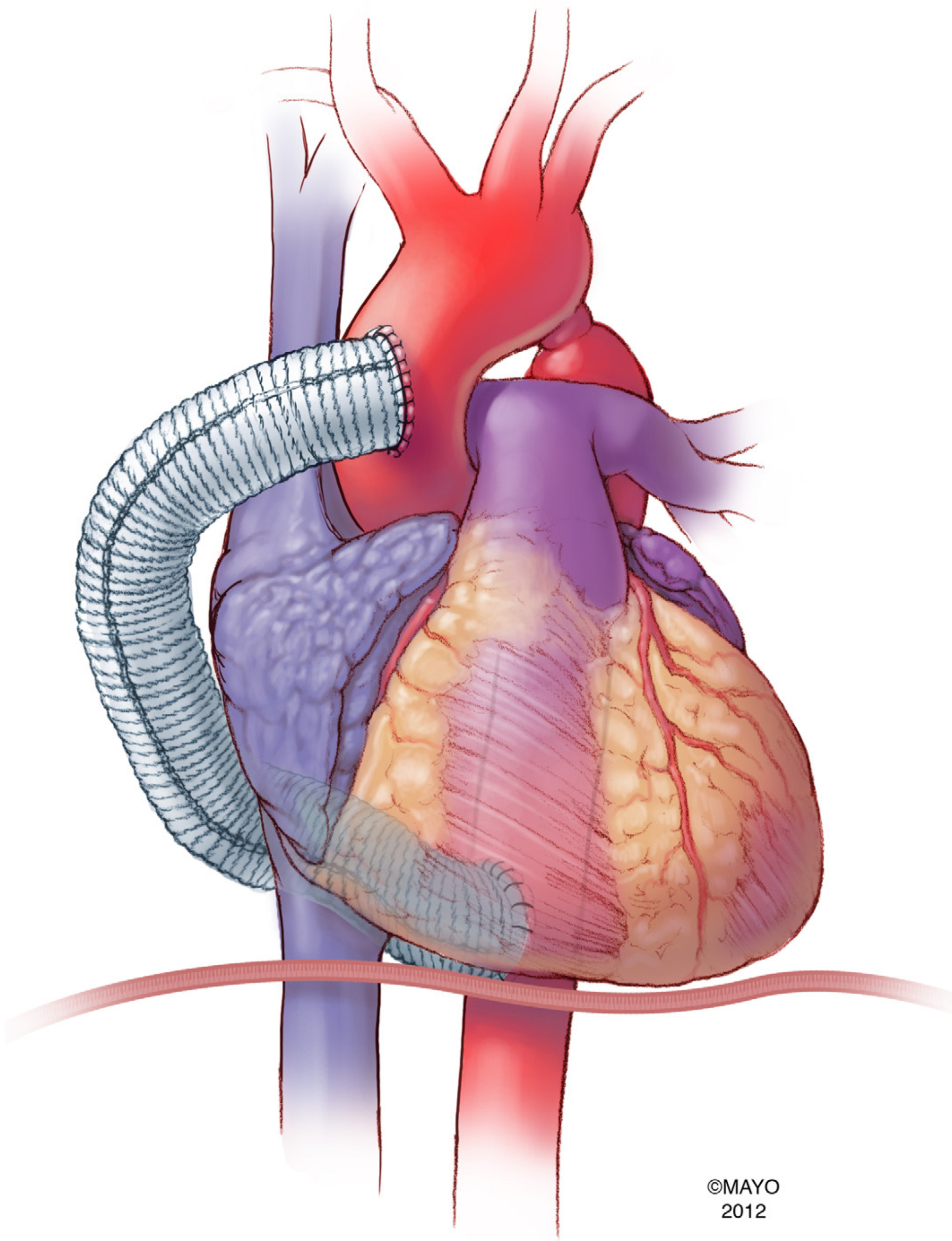

Figure 6 Another option is to route the graft posterior to the inferior vena cava and then along the free wall of the right atrium. (Used by permission of Mayo Foundation for Medical Education and Research. All rights reserved.) (Color version of figure is available online at http://www.optechtcs.com.)

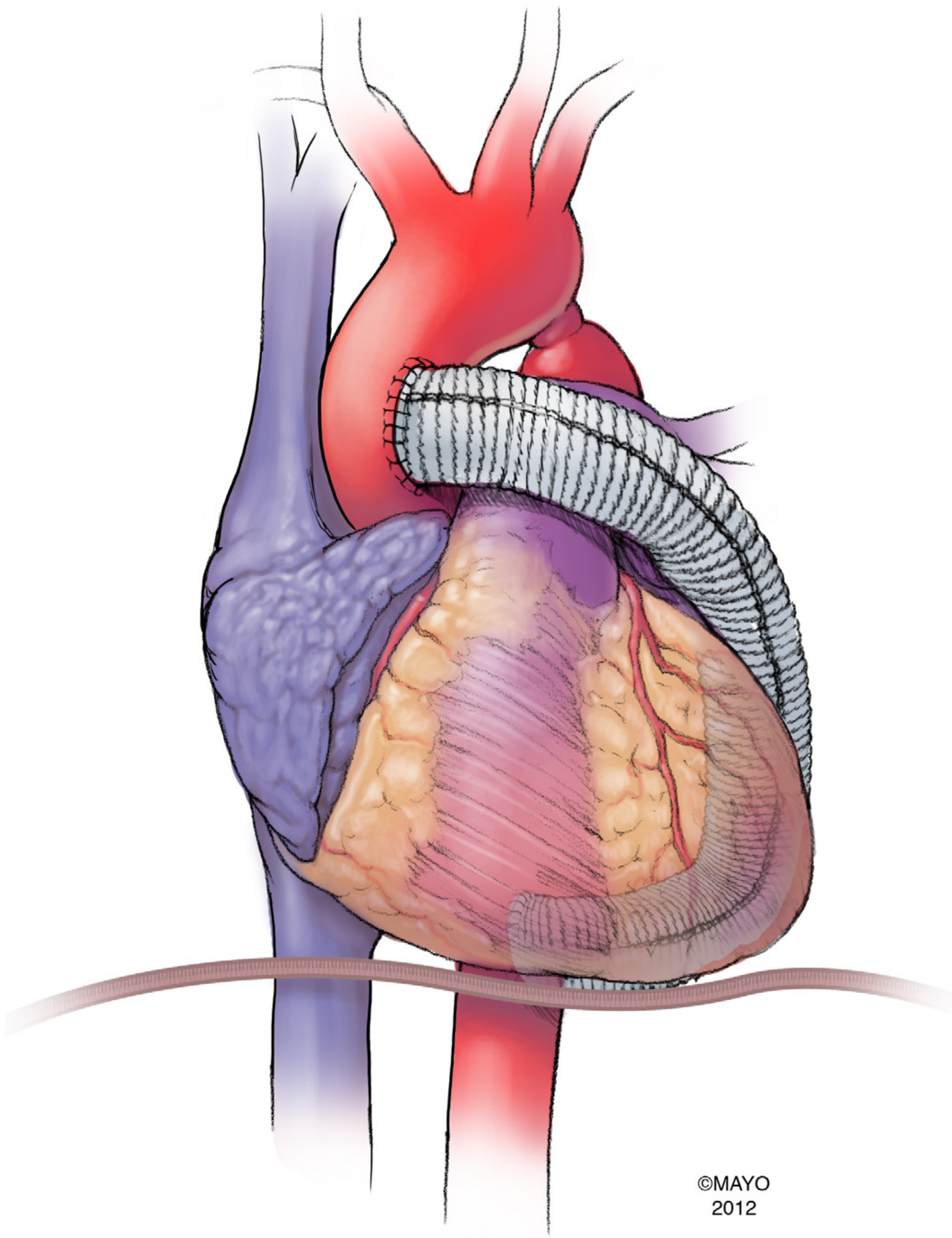

Figure 7 The third option is to direct the graft behind the left ventricle and on top of the main pulmonary artery before constructing the proximal anastomosis. (Used by permission of Mayo Foundation for Medical Education and Research. All rights reserved.) (Color version of figure is available online at http://www.optechtcs.com.)

side (Fig. 7), behind the left ventricle and on top of the main pulmonary artery before joining the ascending aorta. The choice between these different routes will depend in part on the surgeon's experience, the anatomical and operative circumstances, and also the potential need for future cardiac surgery. An appropriate location on the ascending aorta is chosen for the proximal anastomosis. We prefer positioning the proximal anastomosis on the far distal portion of the lateral aspect of the ascending aorta as this will facilitate an aortotomy in future surgery. The proximal anastomosis is

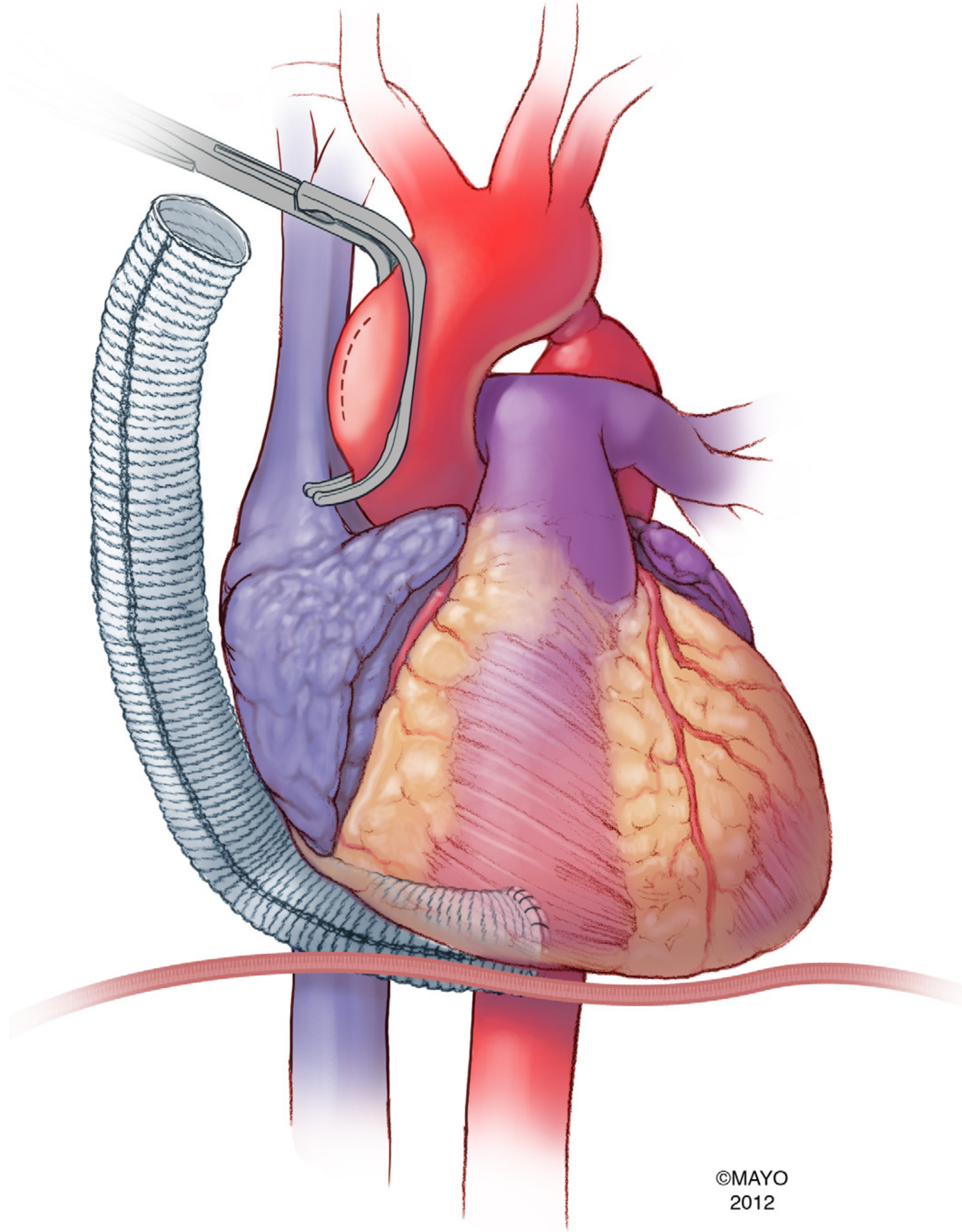

Figure 8 The proximal anastomosis is constructed in a similar fashion to the distal anastomosis. A side-biting clamp is applied on the distal ascending aorta. (Used by permission of Mayo Foundation for Medical Education and Research. All rights reserved.) (Color version of figure is available online at http://www.optechtcs.com.)

performed in the same manner as the distal anastomosis using a partial occluding clamp (Fig. 8) and a running 4-0 polypropylene suture (Fig. 9). Rarely, another option is performing either the descending or the ascending anastomosis with deep hypothermia and a brief period of circulatory arrest if the size of the aorta is so small that partial occlusion results in inadequate distal perfusion or extensive adhesions precludes safe dissection of the aorta. This operation is applied when somatic growth is complete. Kanter et al[4] advocated the use of the posterior pericardial approach without cardiopulmonary bypass.

Mayo Clinic Experience

We performed 75 ascending-descending bypasses between January 1985 and September 2012. The first 50 cases have been reported recently.[5] The mean age at operation was 42 years (range, 15-67 years). The main indications for surgery were uncontrollable hypertension in association with complex coarctation, and recurrent coarctation. Ascending–descending bypass was possible in all 50 patients. Concomitant cardiac procedures were performed in 62% of the patients and the most common of these procedures were aortic valve replacement in 15,

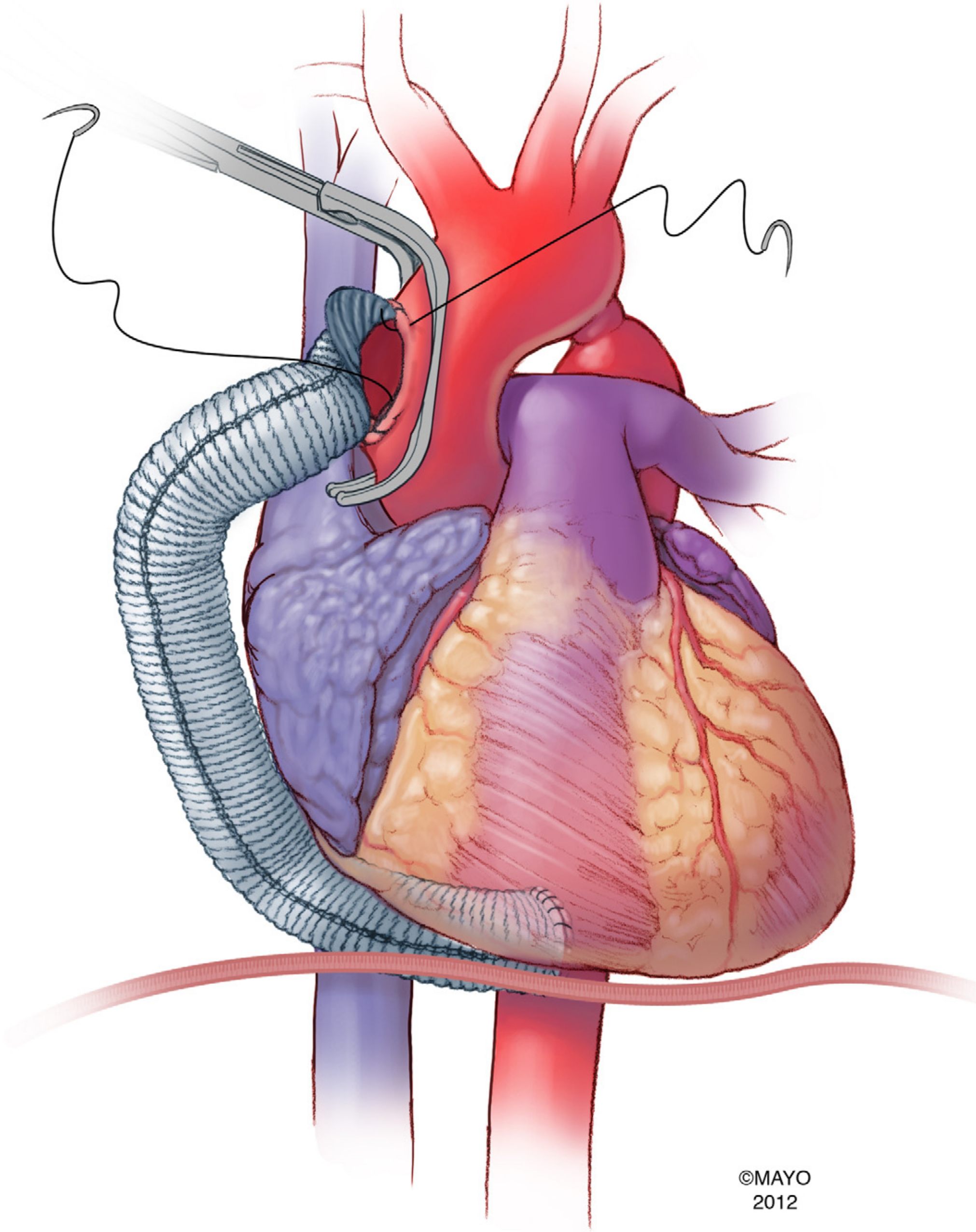

Figure 9 A running 4-0 polypropylene suture is used. The site of the proximal anastomosis should be on the most distal portion of the lateral aspect of the ascending aorta to facilitate potential future aortotomy. (Used by permission of Mayo Foundation for Medical Education and Research. All rights reserved.) (Color version of figure is available online at http://www.optechtcs.com.)

ascending aortic aneurysm repair in 6, septal myectomy in 5, and coronary artery bypass grafting in 4 patients. The mean cardiopulmonary bypass and cross-clamp times were 107 ± 53 and 58 ± 42 minutes, respectively, with no perioperative mortality. Significant improvement in upper extremity blood pressure was found ($P <$ 0.001). There were no graft-related deaths or complications in the follow-up period, which extended to 20 years.

Conclusions

The ascending–descending bypass technique is a safe and durable option for recurrent or complex aortic arch obstruction. The posterior pericardial approach is feasible and can achieve excellent results with low morbidity and mortality.

References

1. Zoghbi J, Serraf A, Mohammadi S, et al: Is surgical intervention still indicated in recurrent aortic arch obstruction? J Thorac Cardiovasc Surg 127:203-212, 2004
2. Warnes CA, Williams RG, Bashore TM, et al. American College of Cardiology/American Heart Association 2008 guidelines for the management of adults with congenital heart disease. Circulation 118:e714-e833, 2008
3. Burkhart HM, Dearani JA, Connolly HM, et al: Ascending-descending posterior pericardial bypass of complex coarctation of the aorta. Semin Thorac Cardiovasc Surg Pediatr Card Surg Annu 14:116-119, 2011
4. Kanter KR, Erez E, Williams WH, et al: Extra-anatomic aortic bypass via sternotomy for complex aortic arch stenosis in children. J Thorac Cardiovasc Surg 120:885-890, 2000
5. McKellar SH, Schaff HV, Dearani JA, et al: Intermediate-term results of ascending-descending posterior pericardial bypass of complex aortic coarctation. J Thorac Cardiovasc Surg 133:1504-1509, 2007